Adaptive Management Set-Up Phase Step 5: Monitoring Program

Adaptive Management: Process

- Select management action based on:
  - (1) objectives
  - (2) available actions
  - (3) estimated state of system*
  - (4) models *
- Selected action drives system to new state, identified via monitoring program *
- Compare estimated and predicted system state to assess credibility of models *
- Return to first step

* Based on monitoring program

Roles of Monitoring in Adaptive Management

- Determine system state for state-dependent decisions
- Determine system state to assess degree to which management objectives are achieved
- Determine system state for comparison with model-based predictions to learn about system dynamics (i.e., do science)
- Provide estimates of parameters for model development and updating

Role of Monitoring: State-dependent Decisions

- Use estimates of system state for state-dependent management decisions
- Optimal decision = *f*(system state)
- Example: different harvest decisions depending on whether population size is too small, too large, or at desired level

State-dependent Decision Table

Millions of Mallards	Hunting Regulations
<4	Restrictive
4-5	Restrictive
5-6	Moderate
6-7	Liberal
7-8	Liberal
>8	Liberal

Role of Monitoring: Assess System Performance

- Monitoring of goal-related variables permits performance assessment
- Goals may be functions of the system state variable(s)
- Goals may include functions of other variables (e.g., accumulated harvest) estimated from the monitoring program

Role of Monitoring: Assessing Models of System Dynamics

- Estimates of state (and other) variables obtained from monitoring are compared against model-specific predictions (science)
- Credibility is increased for models that predict well and decreased for models that predict poorly
- Changes in model credibility over time are a key aspect of learning in the adaptive management process

Role of Monitoring: Developing and Updating Models of System Dynamics

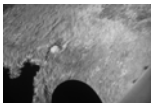
- Parameter estimates needed for developing and updating models (e.g., revised estimates of distribution of harvest rates resulting from different hunting regulations)

How to Monitor? Basic Sampling Issues

- Geographic variation
  - Frequently counts/observations cannot be conducted over entire area of interest
  - Proper inference requires a spatial sampling design that permits inference about entire area, based on a sample

How to Monitor? Basic Sampling Issues

- Detectability:
  - Counts represent some unknown fraction of animals in sampled area
  - Proper inference requires information on detection probability



Monitoring Program: Summary

- Monitoring data: multiple uses in the adaptive management process
- Monitoring program is developed with those specific uses in mind
- Monitoring program design is tailored to management uses, with attention to:
  - Geographic variation
  - Detectability

Monitoring and NEPA

Monitoring for Adaptive Management Purposes

- Provides data to
  - Evaluate progress towards achieving objectives
  - Determine resource status in order to identify appropriate management actions
  - Increase understanding of resource dynamics
  - Help improve or refine models

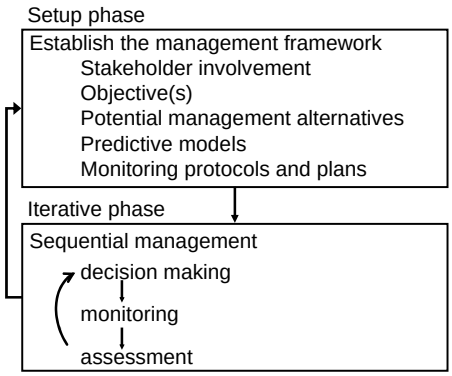
Monitoring and NEPA

- Needed for the same reasons as adaptive management
- Allows for an evaluation of impacts predicted and those actually occurring
- Provides a basis/justification for adjusting management actions
- Provides a public outreach opportunity
- Meets regulatory requirements of NEPA regarding monitoring requirements for mitigation (40 CFR 1505.2)

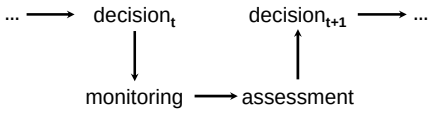
Points of Emphasis in Technical Guide

- AM is science-based, objective-driven decision making
- AM integrates science and management
- AM is explicit about objectives, management options, assumptions, uncertainties
- AM requires stakeholder involvement and shared decision making

Adaptive Resource Management



Sequential Operation of AM



- Decisions are guided by management objectives at each time
- Monitoring is used to track system responses to management
- New information from monitoring is combined with previously collected information and models to produce improved understanding
- Decisions are adjusted in the next time period based on that improved understanding